National Radio Astronomy Observatory
Socorro, NM 87801

VLA TEST MEMO 211

BANDWIDTH EXPANSION: 3 ANTENNA - 4 IF TESTS

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ABSTRACT
The modifications to test signal to noise ratio (SNR) improvement for increased continuum bandwidth (more than 50 MHz) for all four IFs on three antennas have been completed recently. The bandwidth is increased to 70 MHz from present maximum 3 dB filter bandwidth of 46 MHz in nominal 50 MHz position for Antenna Nos. 13,18 and 27. A comparision of blank field noise measurements shows a SNR improvement of about 24% with the wideband system over what is achieved using present 50 MHz system. The phase closure errors are $\leq 0.5°$ in the wideband case.

INTRODUCTION

The VLA correlator has twice the number of multipliers than are necessary for the continuum work. This enables the measurements of complex correlation and thus allows increasing the continuum bandwidth up to 100 MHz using the existing 100 MSamples/sec samplers. It was proposed to increase the continuum bandwidth beyond 50 MHz (VLA Electronics Memo. 227) in 1996. Electronics of one IF on two antennas was modified in 1997 to demonstrate the SNR improvement and it performed as expected (VLA Test Memo 205).

Encouraged by those tests it was decided to modify all four IFs on three antennas to find out practical limitations of implementation and determine resulting SNR improvement. We have now modified electronics of all four IFs on Antennas 13, 18 and 27. Also Ken Sowinski has made available the online software necessary to measure full complex correlation necessary to make these tests. This memo describes the hardware modifications necessary and test results using the system.

MODIFICATIONS

The hardware modifications made are shown in the block diagram (Fig. 1), and are:
1. Add 1030/90 MHz BPFs in F7 filter position 3 (4 filters/ant).
2. Change F8 IF filters from 1325/60 to 1330/85 MHz for IF A, from 1425/60 to 1430/85 MHz for IF B, from 1575/60 to 1580/85 MHz for IF C, and from 1675/60 to 1680/85 MHz for IF D.
3. Add a 1500/560 MHz bandpass filter at the input of T3 module.
4. Bias T3 SSB mixer diodes in IF A using 5.6 kOhms resistors and -28V supply.
5. Add a 90 MHz notch filter in T3 IF A SSB mixer output.
6. Replace external JPL filter in T4 by 26 dB attenuator.

7. Adjust Screen room bulkhead 70 MHz LPF delay to match it from unit to unit to ≤ 1 nsec out to 68 MHz.

F7 and F8 filters were built in-house by Paul Lilie and 1500/560 MHz BPF and 90 MHz notch filters were purcahsed at the cost of less than about $1K/antenna.

With above modifications spectra were measured for all three antennas using a Tektronix model 2710 Spectrum Analyser. Fig. 2 shows spectra measured at the D-rack T2 RCV IF front panel BNC monitor. The spectra at T3 front panel BNC monitors are shown in Fig. 3. The spectra measured at the inputs of the sampler racks are shown in Fig. 4 (Note that the spectra for IFs A and D at the sampler rack inputs, shown in Fig. 4, were measured with different filters at the Screen room bulkhead). Considering the spectra in figures 2-4 it seems possible to increase the system bandwidth to about 75 MHz instead of 70 MHz, though this may require correcting slight roll off beyond 70 MHz in about 10% of IFs. Also this may increase the closure errors slightly.

In addition it may be necessary to reduce the gain of the T5 detectors to about 60% of what it is now. This is because output from some of these detectors are reaching or exceeding 10.2 Volts limit where the monitor system saturates. This can only be done once we decide to make this modification in all the antennas.

TEST OBSERVATIONS AND RESULTS

We made continuum observations on 3C84 at X-band for about 3 min and a blank field 5° north of it for about 27 min, using 50 MHz and repeated the observations with wide bandwidth system. In both cases we used 1.67 sec integration and recorded visibility amplitudes and phases for all three baselines for each of the four IFs using full complex correlation measurements.

A comparision of the SNR improvement for 50 MHz continuum observations using full complex correlation and normal correlation has been made separately (VLA Test Memo 210). The full complex correlation increases the SNR by about 8% over measurements using normal correlations.

The average and rms of the amplitudes for 3C84 and the blank field for 50 MHz continuum and wideband observations are given in Table 1. A comparision of the results show that on average the SNR improvement for wideband over 50 MHz is about 14.6% with both observations using complex correlation measurements. There are about 960 measurements for each baseline for the blank field noise observations and therefore statistical uncertainty, when 12 measurements for all four IFs are combined, is about 1.3 % of the 14.6 % SNR improvement. This is small compared with other sources of uncertainties in the measurements and can be ignored. When we account for 8% increase in the SNR for 50 MHz complex correlation versus normal correlation (VLA Test Memo. 210) the net improvement in the SNR for wideband continuum is about 24% over what is presently achieved using normal 50 MHz system. This is close to what is expected for a 70 MHz bandwidth over nominal backend filter bandwidth of 46 MHz for the 50 MHz bandwidth operations.

The average of phase measurements on the calibrator 3C84 for various baselines during wideband observations are given in Table 2. Also table 2 shows phase closure errors for each of the four IFs for the wideband observations. This shows that the phase closure errors are $\leq 0.5°$ which seems reasonable phase closure performance.

CONCLUSION

The electronics of all four IFs on three antennas have been modified. This increases the continuum bandwidth to about 70 MHz. The present maximum continuum bandwidth is limited by 3 dB filter bandwidth of 46 MHz in the nominal 50 MHz bandwidth position. As expected this gives a signal to noise improvement of about 24% over what is presently achieved. The phase closure errors measured for the four IFs are $\leq 0.5°$.

ACKNOWLEDGEMENTS

I thank Ken Sowinski for developing the online software to calculate complex correlations and record them, and the frontend and LO/IF groups and Chuck Broadwell for help in making modifications to the electronics of antennas 13,18 and 27 to carryout these tests.

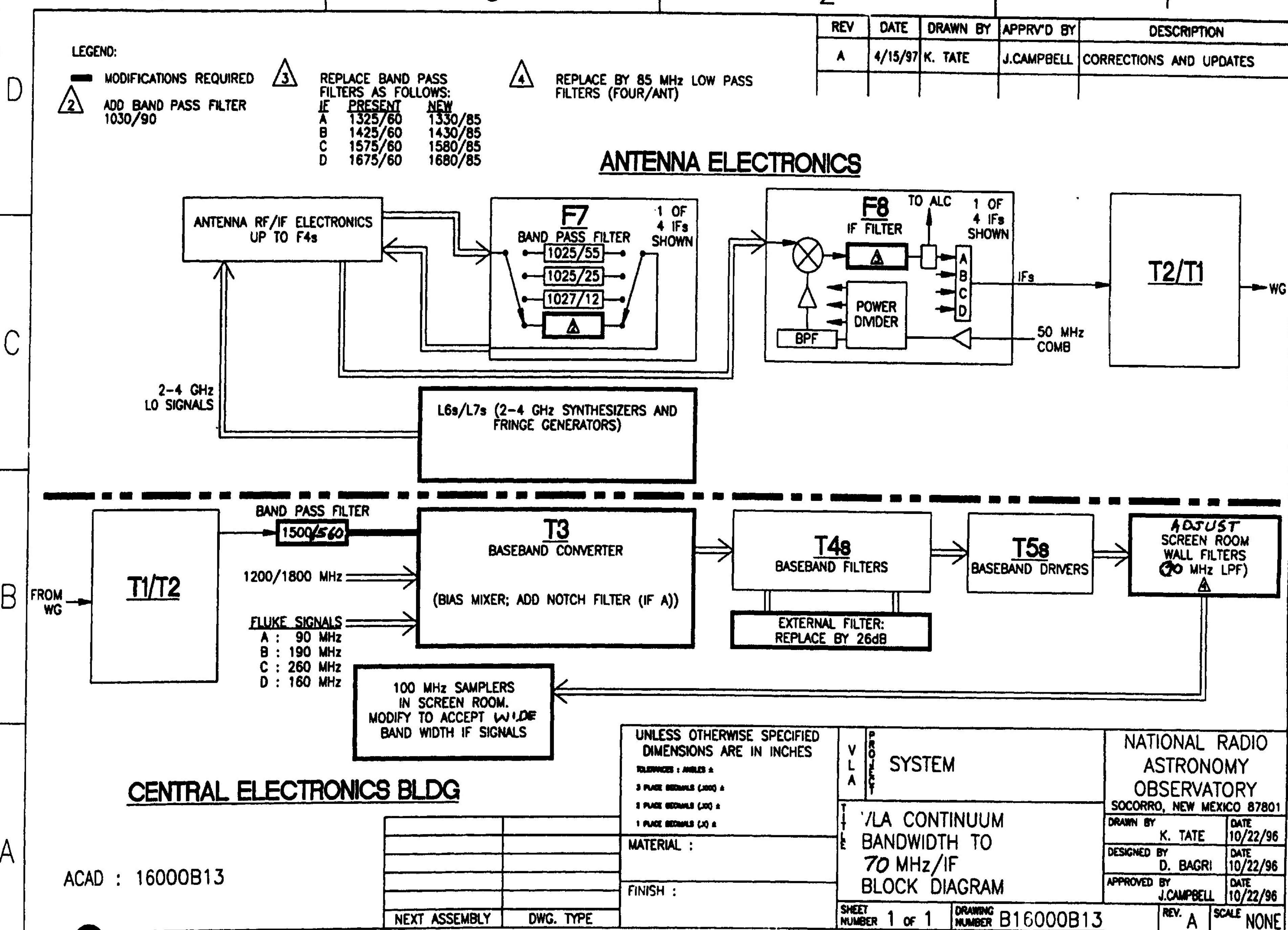
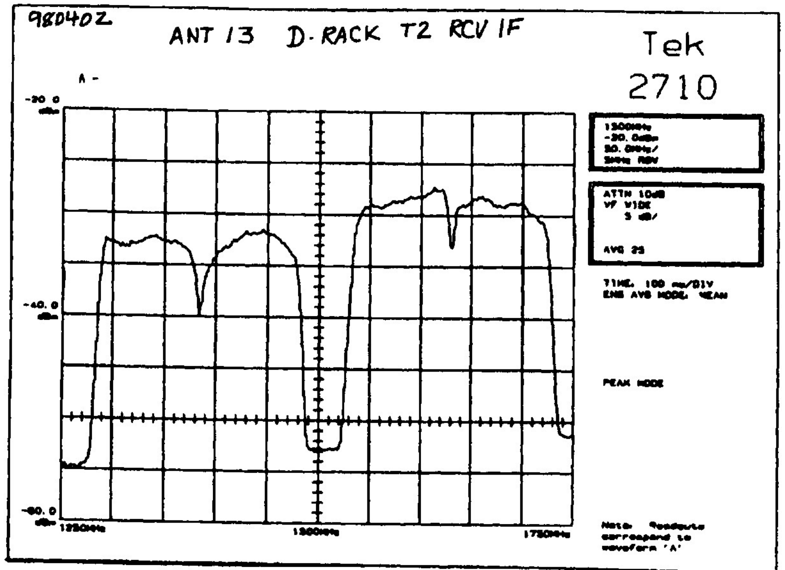
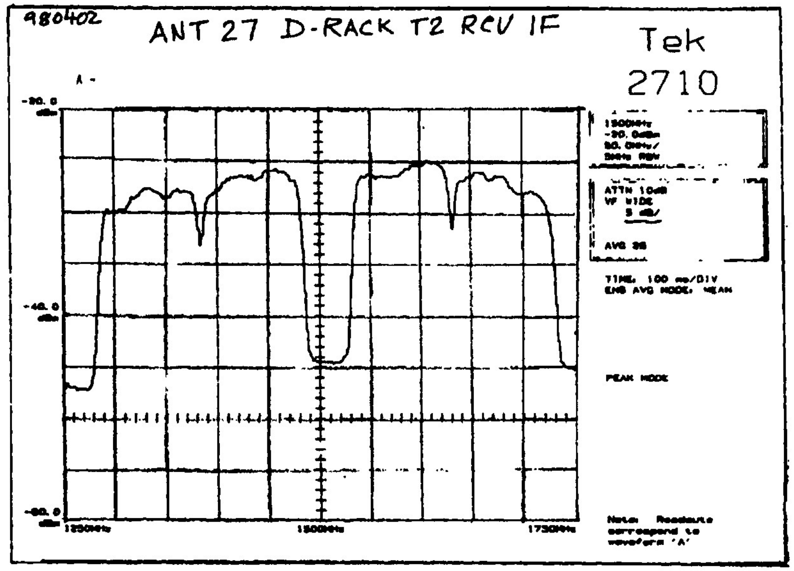


FIG. 1: MODIFICATIONS FOR 3ANTENNA-W[illegible] TESTS; BW = 70MHz, ANTs. 13, 18, 27





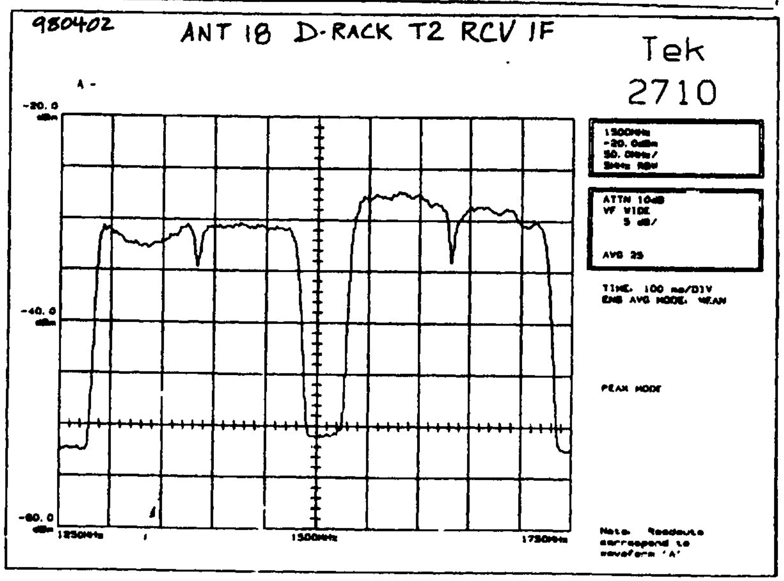
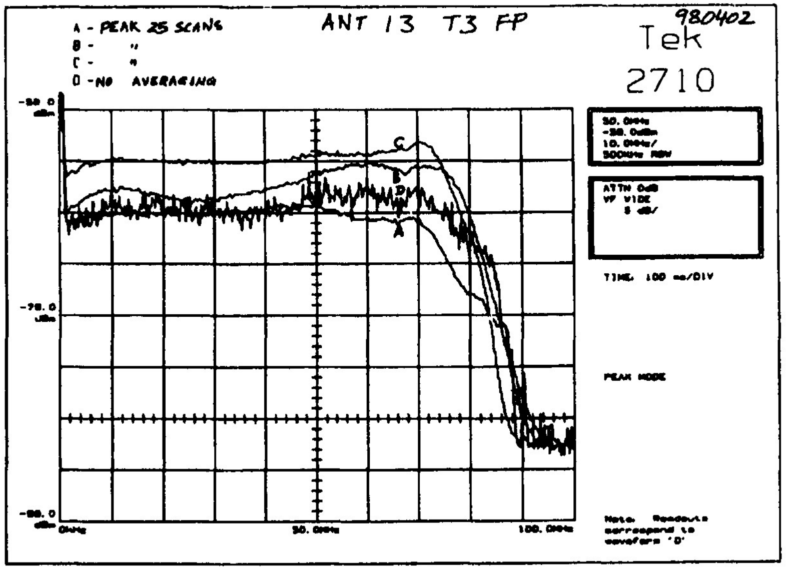
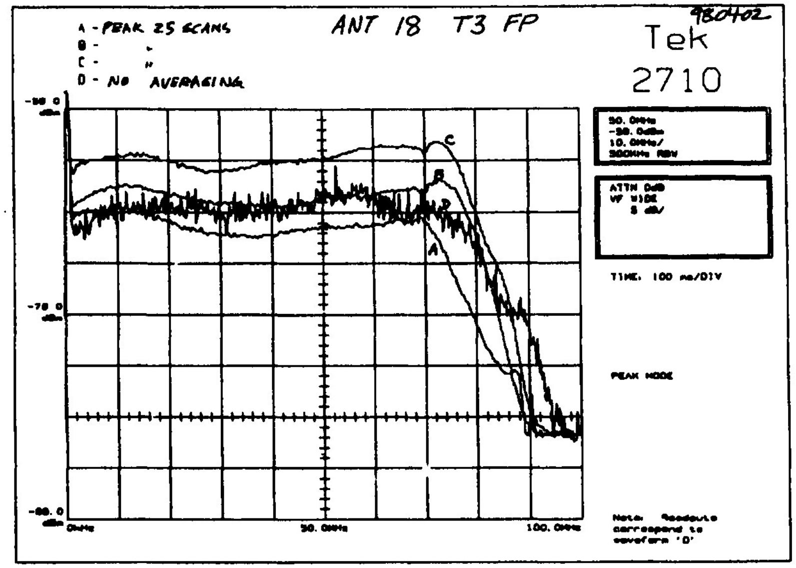


FIG. 2
SPECTRA MEASURED AT D-RACK T2 RCV IF MONITOR (BNC) FOR ANTs 13, 18, 27 WITH WIDEBAND FRONTEND FILTER





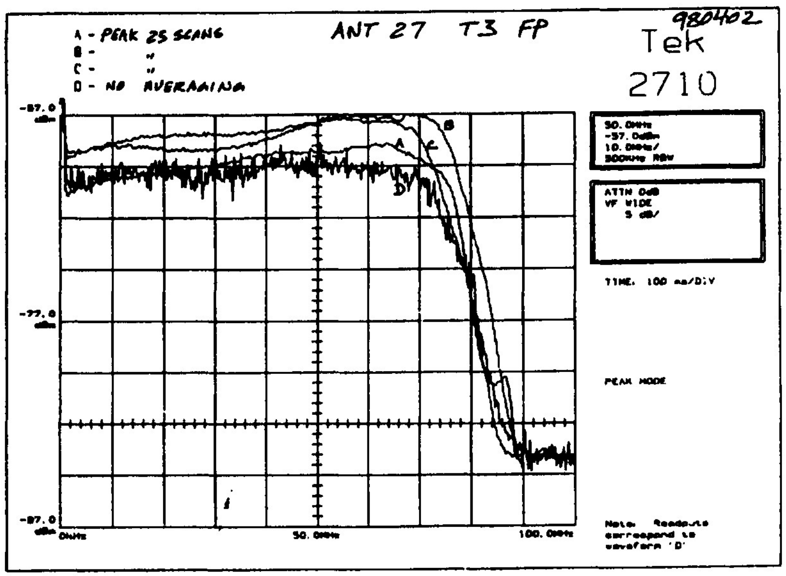


FIG. 3

SPECTRA MEASURED AT T3 FP MONITOR POINTS WITH WIDEBAND FRONTEND (F7 - POS. 3) FILTER. NOTE NO AVERAGING FOR IF D ONLY.

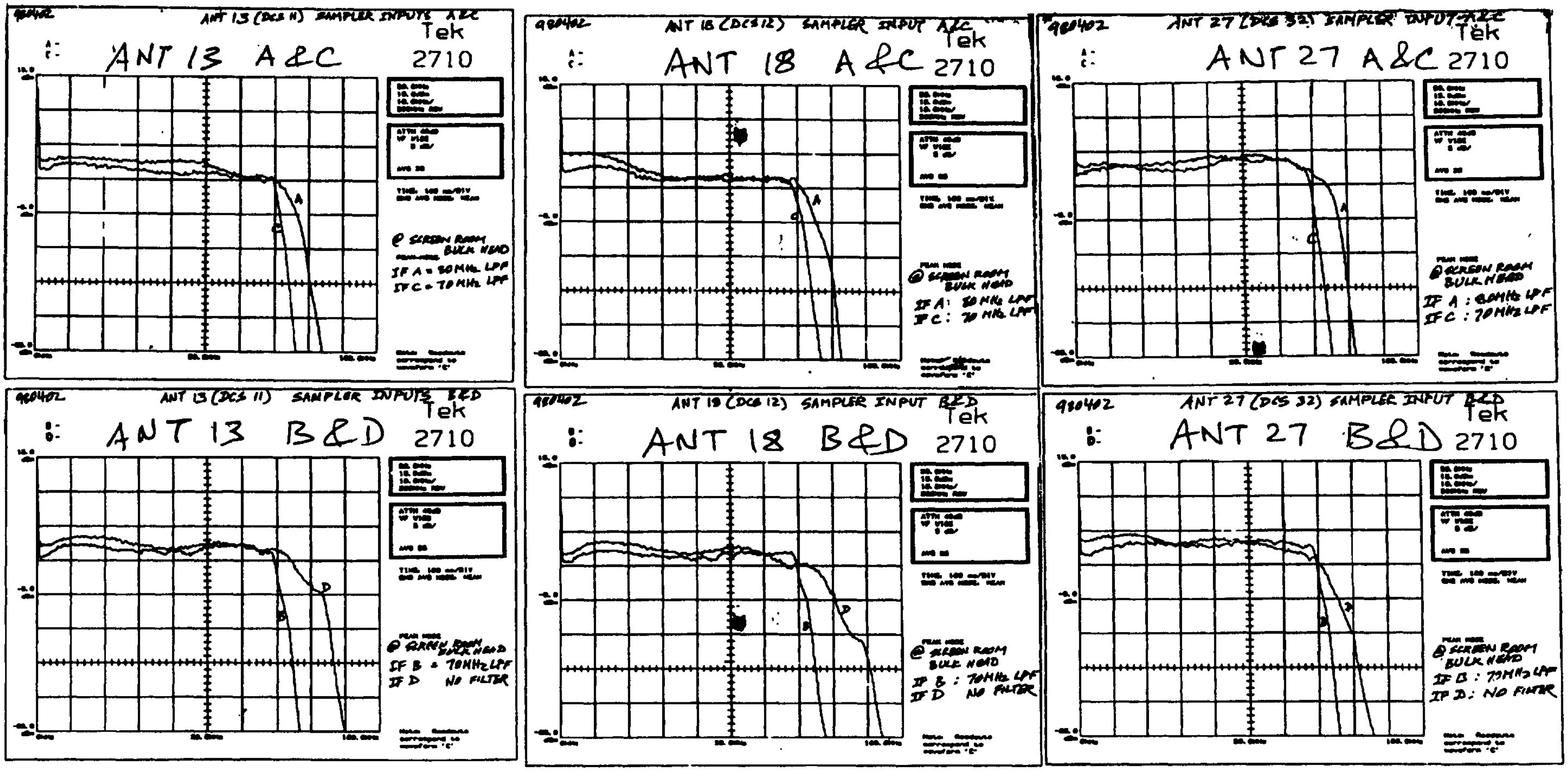


FIG 4 SPECTRA MEASURED AT INPUT OF SAMPLERS

TABLE 1: Average amplitude on 3C84 and rms for a blank field 5 deg North of it for observations usinge 50 MHz continuum and wide bandwidth at X-band

IF	A			B			C			D		
BASELINE	13-18	13-27	18-27	13-18	13-27	18-27	13-18	13-27	18-27	13-18	13-27	18-27
50 MHz:												
3C84 AMP	2.131	2.174	2.082	2.158	2.136	2.099	2.188	2.343	2.223	2.191	2.304	2.176
BLANK RMS(10E-3)	1.852	1.996	2.167	1.891	2.121	2.035	1.922	2.043	2.219	1.914	2.231	2.239
SNR (10E3)	1.151	1.089	0.961	1.141	1.007	1.031	1.138	1.147	1.002	1.144	1.032	0.972
WIDEBAND:												
3C84 AMP	2.102	2.134	2.042	2.167	2.131	2.076	2.212	2.324	2.233	2.20	2.295	2.166
BLANK RMS(10E-3)	1.611	1.697	1.886	1.673	1.792	1.872	1.615	1.888	1.899	1.672	1.880	1.909
SNR (10E3)	1.305	1.258	1.083	1.295	1.189	1.109	1.370	1.231	1.176	1.316	1.221	1.135
SNR IMPROVEMENT WIDEBAND/50 MHz	1.135	1.155	1.127	1.135	1.181	1.075	1.203	1.073	1.174	1.149	1.182	1.167

AVERAGE = 1.146

NET SNR IMPROVEMENT FOR WIDEBAND(70 MHz) OVER PRESENT 50 MHz
= 1.146*1.08 (FOR 50 MHz COMPLEX/50MHz NORMAL CORRELATION)
= 1.238

TABLE 2: Phase closure errors for wideband observations on 3C84 at X-band

IF	A			B			C			D		
BASELINE	13-18	18-27	27-13	13-18	18-27	27-13	13-18	18-27	27-13	13-18	18-27	27-13
	-75.4	-63.3	138.9	122.0	-161.6	39.9	-40.2	91.1	-51.0	120.7	-40.3	-79.9
PHASE CLOSURE=		0.2			0.3			-0.1			0.5	